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A Managerial Decision Support System for Client/Server Computer Network Configuration: A Performance and Resource Utilization Approach

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Abstract

Network design and configuration is frequently studied from a technical perspective alone. However, there are substantial managerial decisions involved in long-term network development and maintenance, which attempts to balance the conflicting demands of cost minimization and faster network performance. Additionally, different network performance measures lead to different design and cost considerations. This research develop a DSS model to aid managers in designing and planning network configurations to maximize resource utilization and minimize network access and application delay times.

Introduction

This research aims to develop a decision support system (DSS) to aid Local Area Network (LAN) managers and other computer professionals to study, formulate and implement strategies related to the choice of a computer networking architecture in an organization. Cost, long term network performance and customer (user) satisfaction are major decision factors in any undertaking of network design and implementation. We look at this problem from the viewpoint of a managerial decision process, including long term commitment, rather than from the standpoint of technical specifications alone. We take into account the projected demand growth of users and applications, the resultant incremental increase in load on the existing system and related cost issues, and study the intricacies of the managerial decision process related to the adoption of the new networking technology.

It is a relatively long term decision to use a particular computer network, hence the risks and uncertainties associated with the decision are also high, especially because this particular technology is evolving and fast-changing. Also, the relative importance of various performance parameters in this specific technology are somewhat dependent on the judgmental decision process of the managers entrusted with choosing the system. Hence, it is worthwhile to develop a decision aid to choose a network system and assist the manager to overcome his or her judgmental bias in choosing the best cost-effective network configuration.

Literature Review and Research Objectives

The impact of information technology (IT) and computers in office automation and mission critical operations has been the focus of various studies in the information systems area (Cronan, et. al.,1995, Alexander, et. al., 1994, Cosares, et. al., 1995, Marakas, 1994, Bux, 1984 and Tanenbaum, 1988). In recent years, the advent of the Internet has boosted the importance and impact of computer networks and related applications worldwide. Choice of a LAN and subsequent enterprise-wide networking has assumed significant importance in recent times, and their use has been accelerated by: (i) technological advances in telecommunication systems, and (ii) difficulties in satisfying organizational needs for geographically dispersed information (Nolan, 1984 and Stonebraker, 1989).

The primary incentive for distributed database implementation in LAN is load balancing, while locality of reference is a big motivator for Wide Area Network (WAN) based distributed databases. Most work on file allocation and data communications has been done on WANs (Ozsu and Valduriez 1991). This paper attempts to aid in and solve the decision problem of LAN design and configuration and load balancing between channels, servers and clients in a network.

Various techniques and topologies have been developed and standardized for LANs, such as, carrier sense multiple access with collision detection (CSMA/CD) bus, token bus, token ring and star topologies (Stallings, 1985 and Tanenbaum, 1988). When applications are considered, it is necessary to select the right kind of LAN design to meet the requirements of the data communications system. For this, performance measures based on the same application requirement are often useful. A basic category of LAN performance is related to the properties of medium access protocol (throughput and delay characteristics) (Lefkon, 1987). A study of the access protocol can provide valuable information about overall efficiency of the system. Performance evaluation investigations of this type are usually restricted to the medium, the physical layer and the medium access control (MAC) sublayer. However, performance measures from higher level protocols, for example, Logical Link Control (LLC) layer or the network layer, might provide pertinent information on the service quality perceived by users.

A Wall Street Journal study (WSJ Supplement Aug 2, 1996) noted that cost-effective implementation of a network technology can only be determined by the particular business needs and objectives, and a knowledge of the mission critical and economically sensible functions of the business will help in making sound purchasing and development decisions. Hence, this paper contributes to the literature by developing a DSS aid that will be highly effective in aiding managers to decide on their business networking needs and choose a proper LAN configuration to maximize their return on investment (ROI), and at the same time maintain an acceptable level of user satisfaction.

Network Model

The interactive simulated client-server network system is implemented with the function of data flow control, which works in the following way. For any client station on the network running multiple sessions, each session executes a process, and the time that the LLC station takes to execute the process can be represented by a probability distribution function, which can be specified by the decision maker, using data from various network resource monitors. At the end of process execution, the session issues a requesting message to the server. This requesting message along with its data interrupts the execution of the server's process and launches the acknowledging message routine, which sends an acknowledgment back to the source session. If the server is already in the process of sending an acknowledgment message, the incoming request waits in the queue until the end of the sending process, and then launches the acknowledgment module. After acknowledgment, the interrupted process on the server resumes execution. A session always stops and waits for an acknowledgment to its previous requesting message before it sends its next one.

To establish application-oriented performance measures, additional levels of network architecture are modeled, such as data flow and congestion control problems. The IEEE 802.2 LLC Type 3 service provides the possibility of supporting the application protocol operations using reliable datagrams (Lefkon, 1987). Carrier sense multiple access with collision detection (CSMA/CD) was used as the Medium Access Control (MAC) protocol, as a large number of current LANs use this as their MAC protocol. The model assumes that session sources are non-identical; hence a realistic network environment is simulated. Each session sends 100-500 requests to the server, which can be specified by the decision maker, and each station can have 1 to 3 sessions running simultaneously. The length of the requesting message is fixed at 1000 bits, and the length of the acknowledgment frame is fixed at 512 bits. Processes are assumed to have the same characteristics, so workload is homogeneous and balanced (on average). Data transfer is issued independently, and the effect of lost messages and recovery is considered, for a realistic scenario. This is a major improvement over the simulation model of Stigall and Chen (1990), which assumed homogeneous client stations and ignored recovery mechanisms, and did not consider cost of network configurations.

Cost data trends on the various network resources are tabulated from industry sources. Depending on the network configuration, there is a tradeoff between performance levels and network implementation costs. A graphical representation of the performance-cost ratios for various network configurations and load factors, with different application processes running and accessing the network under various conditions, are investigated.

Results

The simulation is modeled using COMNET III, an industrial strength network simulation tool. The basic decision support model takes five important LAN performance parameters and helps the manager choose the ones which best suits the situation. The manager can then choose the proper configuration to best satisfy the users and get the maximum cost-benefit advantage. The user satisfaction is captured by the system response times and acceptable delays in the application, message and setup areas (Fig. 1). The managerial decision strategy lies in balancing the delay minimization (hence improving user satisfaction and a faster work environment) and server and channel utilization, with the increased cost of installing faster systems.

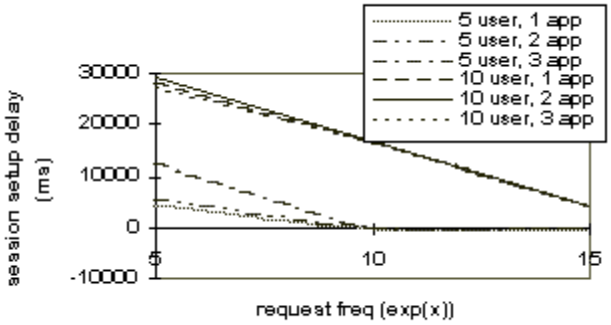

Fig 1: Setup delays for session sources

Post Issues

We are currently investigating the tradeoff between user satisfaction (measured by response times and acceptable delays) and the related resource requirements for various LAN configurations and a variety of application load factors (Fig.2)

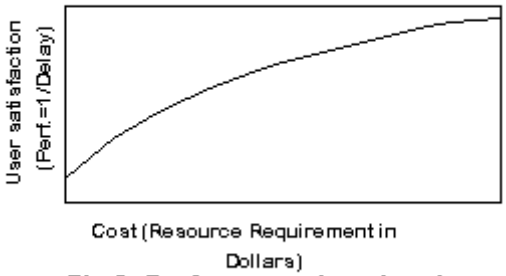

Fig 2: Performance Level and Resource Requirement

Conclusion

This study provides a useful tool for LAN designers and managers to analyze the cost-benefit effects of different network configurations to achieve maximum system utilization and user satisfaction with minimum delays. Additionally, the tool helps managers perform what-if analyses and plan for future network traffic growth and aid in middle to long term resource planning.

References

References are available on request from the authors.